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SEMICONDUCTOR LASER DEVICE AND

METHOD FOR FABRICATING THE SAME

BACKGROUND OF THE INVENTION

5   The present invention relates to a semiconductor laser device composed of a group III-V compound semiconductor and, more particularly, to a semiconductor laser device capable of a high-output and low-voltage operation and to a method for fabricating the same.

Because of their ability to record information at an extremely high density, digital

10   versatile disk (DVD) devices have achieved rapid widespread use in the fields of personal computers and audio-video equipment. In particular, growing expectations have been placed on further proliferation of writable or rewritable DVD devices as, e.g., external large-capacity memory devices (such as so-called DVD-R and DVD-RAM) or as next-generation video recorders (so-called DVD recorders) which are replacements for video

15   tape recorders.

As a pick-up light source used in such a writable or rewritable DVD device to enable reading or rewriting of data, a semiconductor laser device which emits a red light beam at a wavelength of 650 nm has been used. To increase a writing speed in a DVD device, an operation with a high output over 100 mW has been required of a semiconductor

20   laser device in recent years.

In the semiconductor laser device which emits the red light beam, an AlGaInP-based compound semiconductor which is a group III-V compound semiconductor containing at least one of aluminum (Al), gallium (Ga), and indium (In) as a group III element and containing phosphorus as a group V element is used in an active layer and a

25   cladding layer.

FIG. **8** shows a cross-sectional structure of a conventional semiconductor laser device composed of an AlGaInP-based compound semiconductor. As shown in FIG. **8**, the conventional semiconductor laser device is constituted by: an n-type substrate **101** made of gallium arsenide (GaAs); an n-type cladding layer **102** made of n-type AlGaInP; an active layer **103** composed of a multiple quantum well layer **103a** consisting of well layers made of GaInP and barrier layers made of AlGaInP, which are alternately stacked, and upper and lower optical guide layers **103b** made of AlGaInP and formed with the multiple quantum well layer **103a** interposed therebetween; a first p-type cladding layer **104** made of p-type AlGaInP; an etching stopper layer **105** made of p-type GaInP; a ridge-shaped second p-type cladding layer **106** made of p-type AlGaInP; a first contact layer **107** made of p-type GaInP; a first current blocking layer **108** made of n-type AlInP and formed to sandwich the second p-type cladding layer **106**; a second current blocking layer **109** made of n-type GaAs; and a second contact layer **110** made of p-type GaAs.

An n-side electrode **111** made of a metal material is formed on the lower side of the n-type substrate **101** to make ohmic contact therewith, while a p-side electrode **112** made of a metal material is formed on the upper side of the second contact layer **109** to make ohmic contact therewith.

In the conventional semiconductor laser device, current components injected from the p-side electrode **112** by the application of a specified voltage to the n-side electrode **111** and to the p-side electrode **112** are confined by respective pn junctions between the ridge-shaped second cladding layer **106** and the first current blocking layer **108** and between the first and second current blocking layers **108** and **109** to reach the active layer **103** through the second p-type cladding layer **105** and the first p-type cladding layer **104** and cause radiative recombination in the active layer **103**, so that a laser beam with a wavelength of about 650 nm corresponding to the band gap of the well layer is emitted. In this case, a

multilayer structure composed of the second p-type cladding layer **106**, the first p-type cladding layer **104**, the active layer **103**, and the n-type cladding layer **102** serves as a resonator.

To enable the conventional semiconductor laser device to perform a high-output operation, it is important to heavily dope the first p-type cladding layer **104** with a p-type impurity. If the impurity concentration in the first p-type cladding layer **104** is low, electrons injected from the n-side electrode **111** into the active layer **103** overflows from the active layer **103** to the first p-type cladding layer **104**. The overflow of electrons reduces a threshold current and an operating current so that a sufficient output is not obtained.

If the first p-type cladding layer **104** is heavily doped with a p-type impurity, however, the p-type impurity is diffused into the active layer **103** to form a nonradiative recombination center so that the temperature characteristic of the semiconductor device deteriorates and the reliability thereof is degraded.

The provision of an undoped spacer layer between the active layer **103** and the first p-type cladding layer **104** prevents the diffusion of the p-type impurity into the active layer **103** even if the p-type impurity concentration in the first p-type cladding layer **104** is increased.

By doping the first and second p-type cladding layers **104** and **106** with magnesium (Mg) with a low diffusion coefficient, the p-type impurity becomes less likely to be diffused into the active layer **103** so that the p-type impurity concentration in each of the semiconductor layers is increased.

In the conventional semiconductor laser device, however, currents are confined in the ridge-shaped second p-type cladding layer **106**, pass through the first p-type cladding layer **104**, while being diffused therein, and reach the active layer **103**. Consequently, the

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currents are diffused not only in the portion of the first p-type cladding layer **104** underlying the second p-type cladding layer **105** but also in the other region of the first p-type cladding layer **104**. In the region of the active layer **103** other than the portion thereof underlying the second p-type cladding layer **105**, therefore, a sufficient current density for

5   the oscillation of a laser beam cannot be obtained.

Thus, the conventional semiconductor laser device described above has a problem that a high output cannot be obtained therefrom because ineffective currents resulting from the diffusion of currents in the cladding layer formed on the active layer reduce a luminous efficiency and increase a threshold current as well as an operating current.

10   If the impurity concentration in the first p-type cladding layer **104** is increased to suppress the overflow of electrons, the electric conductivity of the first p-type cladding layer **104** is increased so that a current is more likely to be diffused even in a direction parallel with the first p-type cladding layer **104** and the ineffective currents are increased disadvantageously.

15   **SUMMARY OF THE INVENTION**

It is therefore an object of the present invention to solve the foregoing conventional problems and thereby enabling a semiconductor laser device to perform a high-output operation by reducing an ineffective current resulting from the diffusion of a current in a cladding layer.

20   To attain the foregoing object, a semiconductor laser device according to the present invention comprises: an active layer; and a first cladding layer formed on the active layer, the first cladding layer being doped with a first impurity to have a high resistivity.

In the semiconductor laser device according to the present invention, the resistivity of the first cladding layer has been increased so that a driving current for the

25   semiconductor laser device is less likely to be diffused in the first cladding layer. This

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reduces an ineffective current and allows efficient injection of the current into the active layer, thereby enabling a high-output operation. Since the first cladding layer is constituted such that the resistivity thereof is increased through doping with the first impurity, the carrier concentration and compound composition of the first cladding layer need not be

5   changed so that the electric characteristic of the semiconductor laser is not degraded.

Preferably, the semiconductor laser device according to the present invention further comprises: a second cladding layer formed on the first cladding layer, the second cladding layer being doped with a second impurity to have a resistivity lower than the resistivity of the first cladding layer.

10   The arrangement achieves a reduction in the series resistance of the semiconductor laser device and enables the semiconductor laser device to perform a high-output operation by reducing the threshold current and operating current thereof.

In the semiconductor laser device according to the present invention, the first and second cladding layers are preferably made of respective compound semiconductors

15   having substantially the same mobilities.

The arrangement allows the respective resistivities of the first and second cladding layers to be set individually by using different impurities for doping and allows the resistivity of the first cladding layer to be higher than that of the second cladding layer.

In the semiconductor laser device according to the present invention, each of the

20   first and second cladding layers is preferably made of a compound semiconductor containing phosphorus, the first impurity is preferably magnesium, and the second impurity is preferably zinc.

Since magnesium used as a dopant lowers the mobility of carriers in a compound semiconductor containing phosphorus to a higher degree than zinc, the resistivity of the

25   first cladding layer becomes higher than the resistivity of the second cladding layer.

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In this case, a concentration of the first impurity in the first cladding layer is preferably not less than 5×10^{16} cm^{-3} and not more than 1×10^{18} cm^{-3}. The arrangement reliably suppresses the diffusion of the first impurity into the active layer, while increasing the resistivity of the first cladding layer.

5 In the semiconductor laser device according to the present invention, the first cladding layer preferably also contains a third impurity.

Since the arrangement allows an increased impurity concentration in the first cladding layer, the overflow of the carriers injected in the active layer into the first cladding layer can be suppressed so that the temperature characteristic of the 10 semiconductor laser device is improved.

In the semiconductor laser device according to the present invention, each of the first and second cladding layers is preferably made of a compound semiconductor containing phosphorus, the first impurity is preferably magnesium, and each of the second and third impurities is preferably zinc.

15 In this case, a total concentration of the first and third impurities in the first cladding layer is preferably not less than 1×10^{18} cm^{-3} and not more than 5×10^{18} cm^{-3}.

In the semiconductor laser device according to the present invention, each of the first and second cladding layers is preferably made of a compound semiconductor containing arsenic, the first impurity is preferably carbon, and the second impurity is 20 preferably zinc.

In the semiconductor laser device according to the present invention, the second cladding layer is preferably formed into a ridge-shaped configuration on the first cladding layer.

In the semiconductor laser device according to the present invention, the second 25 cladding layer preferably has a lower portion thereof formed into a stripe configuration.

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A method for fabricating a semiconductor laser device according to the present invention comprises the steps of: forming an active layer on a substrate; and forming a first cladding layer on the active layer, while doping the first cladding layer with a first impurity, wherein in the step of forming the first cladding layer, the first impurity is doped so that

5   the first cladding layer has a high resistivity.

In accordance with the method for fabricating a semiconductor laser device of the present invention, the resistivity of the first cladding layer has been increased to have a high value so that a current component diffused in the first cladding layer is reduced. Therefore, a semiconductor laser device capable of a high-output operation can be obtained.

10   Preferably, the method for fabricating a semiconductor laser device according to the present invention further comprises the step of: forming a second cladding layer on the first cladding layer, while doping the second cladding layer with a second impurity, wherein in the step of forming the second cladding layer, the second impurities is doped so that the resistivity of the first cladding layer is higher than a resistivity of the second

15   cladding layer.

In the method for fabricating a semiconductor laser device according to the present invention, each of the first and second cladding layers is preferably made of a compound semiconductor containing phosphorus, the first impurity is preferably magnesium, and the second impurity is preferably zinc.

20   In the method for fabricating a semiconductor laser device according to the present invention, the step of forming the first cladding layer preferably includes doping the first cladding layer with a third impurity in addition to the first impurity.

In the method for fabricating a semiconductor laser device according to the present invention, each of the first and second cladding layers is preferably made of a

25   compound semiconductor containing phosphorus, the first impurity is preferably

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magnesium, and each of the second and third impurities is preferably zinc.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph for illustrating the principle of problem solution used in each of the embodiments of the present invention, which shows a relationship between the doping concentration in a semiconductor layer made of AlGaInP and the resistivity thereof;

FIG. 2 is a structural cross-sectional view of a semiconductor laser device according to the first embodiment of the present invention;

FIG. 3 is a graph showing a relationship between the resistivity and threshold current of a first p-type cladding layer in the semiconductor laser device according to the first embodiment;

FIGS 4A and 4B are structural cross-sectional views illustrating the individual process steps of a method for fabricating the semiconductor laser device according to the first embodiment;

FIGS. 5A and 5B are structural cross-sectional views illustrating the individual process steps of the method for fabricating the semiconductor laser device according to the first embodiment;

FIG. 6 is a structural cross-sectional view of a semiconductor laser device according to a second variation of the first embodiment;

FIG. 7 is a structural cross-sectional view of a semiconductor laser device according to the second embodiment of the present invention; and

FIG. 8 is a structural cross-sectional view of a conventional semiconductor laser device.

DETAILED DESCRIPTION OF THE INVENTION

Each of the embodiments of the present invention pertains to a semiconductor laser device having an active layer and first and second cladding layers formed

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successively on the active layer. By increasing the resistivity of the first cladding layer, the diffusion of a current in the first cladding layer is suppressed. A description will be given first to the principle of problem solution common to the individual embodiments with reference to the drawings.

5   In the present specification, AlGaInP represents a compound containing at least one of aluminum (Al), gallium (Ga), and indium (In) as a group III element and containing phosphorus (P) as a group V element. In particular, GaInP represents a case where Al is not contained in AlGaInP and AlInP represents a case where Ga is not contained in AlGaInP. On the other hand, AlGaAs represents a compound containing at least one of Al

10   and Ga as a group III element and containing arsenic (As) as a group V element.

FIG. 1 is a graph showing the result of an experiment which measured a relationship between the concentration of a p-type dopant used to dope a semiconductor layer made of AlGaInP (AlGaInP layer) which has been formed by metal organic chemical vapor deposition (MOCVD), while being doped with the p-type dopant and the resistivity

15   of the AlGaInP layer that has been formed. In FIG. 1, the square mark (□) represents data obtained when zinc (Zn) is used as the p-type dopant and the circle mark (○) represents data obtained when magnesium (Mg) is used as the p-type dopant.

The experiment the result of which is shown in FIG. 1 used triethylgallium (TEG), trimethylaluminum (TMA), and trimethylindium (TMI) each as a source gas for a group III

20   compound, used phosphin (PH_3) and arsine (AsH_3) each as a source for a group V compound, and used dimethylzinc ($Zn(CH_3)_2$) or biscyclopentadienyl magnesium ((C_5H_5)$_2$Mg) each as a source for a p-type impurity. As growing conditions, the pressure of a source gas adjusted to about 1.0×10^4 Pa (about 76 Torr) and the substrate temperature adjusted to about 750 °C were used.

25   As shown in FIG. 1, the resistivity of the AlGaInP layer decreases as the doping

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concentration therein increases in either of the cases where Zn is used as a p-type dopant and where Mg is used as a p-type dopant. In general, the resistivity of a semiconductor is inversely proportional to the product of mobility and carrier concentration. The mobility used herein has a value substantially determined by the composition of the semiconductor

5   material.   The carrier concentration used herein has a value which increases as the doping concentration increases. By increasing the doping concentration, therefore, the carrier concentration in the AlGaInP layer increases so that the resistivity thereof is reduced.

It will be understood from FIG. 1 that, if a comparison is made between the respective cases where zinc (Zn) and magnesium (Mg) at the same concentration are used

10   for doping, a lower resistivity is achieved in the case where Zn is used for doping. This is because Mg has a higher effect of scattering carriers in the AlGaInP layer than Zn so that the mobility in the AlGaInP layer is lowered by the scattering of carriers.

In the case of using a group III-V compound semiconductor for a semiconductor laser device, the compound composition and doping concentration of each of

15   semiconductor layers composing the semiconductor laser device are set to specified values such that the semiconductor laser device has desired electric characteristics. If the compound composition and doping concentration are changed, the electric characteristics of the semiconductor laser device deteriorate so that it is difficult to adjust the resistivity to a desired value by changing the doping concentration and compound composition.

20   As described above with reference to FIG. 1, however, the experiment conducted by the present inventors has proved that the value of the resistivity can be adjusted by selecting a dopant species. The semiconductor laser device according to each of the following embodiments has been designed such that the resistivity is adjustable by selecting respective dopant species to be used in the first and second p-type cladding layers

25   made of compound semiconductors having substantially the same mobilities without

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changing the compound composition and doping concentration.

Although the resistivity of the AlGaInP layer is lower in the case of using Zn as a dopant than in the case of using Mg as a dopant in the result of the experiment shown in FIG. 1, there may be a case where Mg used as a dopant in the AlGaInP layer achieves a low resistivity than Zn used as a dopant.

Although the description has been given to the dopants for doping the semiconductor layers made of AlGaInP with reference to FIG. 1, if a comparison is made between the respective cases where carbon (C) and zinc (Zn) are used for doping a semiconductor layer made of AlGaAs, a higher resistivity is achieved in the case of using carbon.

EMBODIMENT 1

The first embodiment of the present invention will be described herein below with reference to the drawings.

FIG. 2 shows a cross-sectional structure of the semiconductor laser device according to the first embodiment. In FIG. 2, the arrows indicate the paths of currents flowing during the driving of the semiconductor laser device.

As shown in FIG. 2, an n-type cladding layer 12 made of n-type $Al_{0.35}Ga_{0.15}In_{0.5}P$ with a film thickness of about 2 μm, an active layer 13 having a multiple quantum well structure made of undoped AlGaInP, a first p-type cladding layer 14 made of p-type $Al_{0.35}Ga_{0.15}In_{0.5}P$ with a film thickness of about 0.2 μm, and an etching stopper layer 15 made of p-type $Ga_{0.5}In_{0.5}P$ with a film thickness of about 10 nm are deposited successively by crystal growth on an n-type substrate 11 made of gallium arsenide (GaAs) with a thickness of about 100 μm. A second p-type cladding layer 16 made of p-type $Al_{0.35}Ga_{0.15}In_{0.5}P$ with a film thickness of about 1 μm and formed into a ridge-shaped configuration and a first contact layer 17 made of p-type $Ga_{0.5}In_{0.5}P$ with a film thickness

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of about 50 nm are formed on the etching stopper layer **15**.

A first current blocking layer **18** made of n-type $Al_{0.5}In_{0.5}P$ with a film thickness of about 0.3 μm and a second current blocking layer **19** made of n-type GaAs with a film thickness of about 0.3 μm are stacked successively to cover the upper surface of the etching stopper layer **15** and the respective sidewall surfaces of the second p-type cladding layer **16** and the first contact layer **17**. A second contact layer **20** made of p-type GaAs with a film thickness of about 3 μm is further formed over the first contact layer **17** and the second current blocking layer **19**.

An n-side electrode **21** made of a metal material composed of an alloy containing, e.g., Au, Ge, and Ni is formed on the lower side of the n-type substrate **11** to make ohmic contact therewith. On the other hand, a p-side electrode **22** made of a metal material composed of an alloy containing Cr, Pt, and Au is formed on the upper side of the second contact layer **20** to make ohmic contact therewith.

The active layer **13** is composed of: a multiple quantum well layer **13a** consisting of well layers each made of $Ga_{0.5}In_{0.5}P$ with a film thickness of about 6 nm and barrier layers each made of $Al_{0.25}Ga_{0.25}In_{0.5}P$ with a film thickness of about 5 nm, which are alternately stacked; and upper and lower optical guide layers **13b** each made of $Al_{0.25}Ga_{0.25}In_{0.5}P$ with a film thickness of about 30 nm to have the multiple quantum well layer **13a** interposed therebetween.

Each of the n-type cladding layer **12**, the first p-type cladding layer **14**, and the second p-type cladding layer **16** is made of a semiconductor material having a larger band gap than any of the semiconductor layers composing the active layer **13**, so that carriers are confined in the active layer **13**. In an AlGaInP-based semiconductor material, the band gap can be increased by relatively increasing the composition of Al. Although the compound semiconductors having the same composition have been used for the first and second p-

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type cladding layers, it is also possible to adjust the composition ratio between Al and Ga in each of the compound semiconductors such that band gaps larger than in the semiconductor layers composing the active layer **13** are provided.

With the second p-type cladding layer **16** formed into a ridge-shaped configuration, the semiconductor layer device according to the first embodiment has a so-called ridge stripe waveguide structure in which the respective portions of the n-type cladding layer **12**, the active layer **13**, the first p-type cladding layer **14**, and the etching stopper layer **15** underlying the second p-type cladding layer **16** and the second p-type cladding layer **16** serve as a waveguide. By using AlInP for the first current blocking layer **18**, an effective index waveguide is provided.

The etching stopper layer **15** is made of a semiconductor material having a low Al composition to exhibit a high etching selectivity to the first p-type cladding layer **14** during etching for forming the second p-type cladding layer **16** into the ridge-shaped configuration such that the first p-type cladding layer **14** is not etched.

On the other hand, GaAs is used for the second contact layer **20** for easy ohmic contact with the metal material. The first contact layer **17** reduces the band discontinuity between the second p-type cladding layer **16** and the second contact layer **20**.

Table **1** shows specific dopant species and doping concentrations in the individual layers of the semiconductor laser device thus constituted.

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Table **1**

Semiconductor Layer	Thickness	Compound Composition	Doping Conditions	
			Dopant	Concentration (cm^{-3})
2nd Contact Layer	3 μm	GaAs	Zn	3×10^{18}
2nd Current blocking layer	0.3μm	GaAs	Si	1×10^{18}
1st Current blocking layer	0.3μm	$Al_{0.5}In_{0.5}P$	Si	1×10^{18}
1st Contact Layer	50 nm	$Ga_{0.5}In_{0.5}P$	Zn	1×10^{18}
2nd p-Type Cladding layer	1 μm	$Al_{0.35}Ga_{0.15}In_{0.5}P$	Zn	1×10^{18}
Etching Stopper Layer	10 nm	$Ga_{0.5}In_{0.5}P$	Mg	1×10^{18}
1st p-Type Cladding layer	0.2μm	$Al_{0.35}Ga_{0.15}In_{0.5}P$	Mg	5×10^{17}

Active Layer
    Quantum Well Layer
        Well Layers
        Barrier Layers
        Optical Guide Layers
	
	6 nm Each
	5 nm Each
	30 nm Each
		
		$Ga_{0.5}In_{0.5}P$
		$Al_{0.25}Ga_{0.25}In_{0.5}P$
		$Al_{0.25}Ga_{0.25}In_{0.5}P$
			
			—
			—
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n-Type Cladding layer	2 μm	$Al_{0.35}Ga_{0.15}In_{0.5}P$	Si	1×10^{18}
n-Type Substrate	100 μm	GaAs	Si	1×10^{18}

As shown in Table 1, each of the first p-type cladding layer **14** and the etching stopper layer **15** is doped with magnesium (Mg) as a p-type dopant and each of the second p-type cladding layer **16** and the first and second contact layers **17** and **20** is doped with zinc (Zn) as a p-type dopant in the semiconductor laser device according to the first embodiment. The doping concentration in the first p-type cladding layer **14** is about 5 x 10^{17} cm^{-3} and the doping concentration in the second p-type cladding layer **16** is about 1 x 10^{18} cm^{-3}. As an n-type dopant, silicon (Si) at a concentration of about 1 x 10^{18} cm^{-3} is used.

On the other hand, Zn is used as a dopant for the second contact layer **20**. This is because, if Mg is used as a dopant for an AlGaAs-based semiconductor, a problem termed delayed doping in which the semiconductor is not doped continuously with Mg even after the supply of a source for Mg is initiated or a problem termed memory effect in which the semiconductor is doped continuously with Mg even after the supply of the source for Mg is halted occurs so that a specified doping concentration is not obtained. Even if Mg is used as a dopant for each of the semiconductor layers made of an AlGaInP-based semiconductor, the problems of delayed doping and memory effect do not occur so that a desired doping concentration is obtained.

In the semiconductor laser device according to the first embodiment, a specified voltage is applied between the n-side electrode **21** and the p-side electrode **22** so that holes injected from the p-side electrode are confined by respective pn junctions between the second p-type cladding layer **16** and the first current blocking layer **18** and between the first and second current blocking layers **18** and **19** to reach the active layer **13** through the first p-type cladding layer **14**. As a result, the holes are injected at a high density in the portion of the active layer **13** underlying the second p-type cladding layer **16** to be radiatively recombined with electrons injected from the n-side electrode **21** so that laser beam oscillation at a wavelength of about 650 nm corresponding to the band gap of the

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well layer occurs.

The first embodiment is characterized in that Mg is used as a dopant (first impurity) for doping the first p-type cladding layer **14** and Zn is used as a dopant (second impurity) for doping the second p-type cladding layer **16**.

5   As described above with reference to FIG. **1**, the semiconductor layer made of AlGaInP has a higher resistivity when it is doped with Zn than with Mg. This allows the first p-type cladding layer **14** to be formed with a resistivity higher than that of the second p-type cladding layer **16** even if respective semiconductor materials having the same components are used for the first and second cladding layers **14** and **16**.

10   That is, the semiconductor laser device according to the first embodiment has been designed such that the first p-type cladding layer **14** has a resistivity higher than that of the second p-type cladding layer **16** by doping the first p-type cladding layer **14** with Zn having a larger carrier scattering effect and doping the second p-type cladding layer **16** having a smaller carrier scattering effect.

15   A description will be given below to the effect achieved by increasing the resistivity of the first p-type cladding layer **14** with reference to the drawings.

FIG. **3** shows variations in the threshold current of the semiconductor laser device according to the first embodiment when the resistivity of the first p-type cladding layer **14** is changed. In FIG. **3**, the abscissa axis represents the resistivity of the first p-type cladding 20   layer and the ordinate axis represents the threshold current of the semiconductor laser device.

It is obvious from FIG. **3** that the threshold current of the semiconductor laser device decreases as the resistivity of the first p-type cladding layer **14** increases. This is because the diffusion of the current is less likely to occur in the first p-type cladding layer 25   **14** as the resistivity of the first p-type cladding layer **14** is higher. Consequently, of current

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components taking paths from the second p-type cladding layer **16** to the active layer **13**, those flowing outwardly of the portion underlying the second p-type cladding layer **16** are reduced so that the current density in the portion underlying the second p-type cladding layer **16** is increased and therefore the current is injected efficiently into the active layer **13**.

5   As shown specifically by the arrows in FIG. **2**, the currents confined by the first and second current blocking layers **18** and **19** flow from the second p-type cladding layer **16** and reach the portion of the active layer **13** underlying the second p-type cladding layer **16** without being substantially diffused in the first p-type cladding layer **14**.

As a result, radiative recombination occurs efficiently in the portion of the active

10   layer **13** underlying the second p-type cladding layer **16**. This reduces the threshold current and operating current of the semiconductor layer device and implements a high-output semiconductor laser device.

Although the etching stopper layer **15** has been heavily doped with Mg, sidewise diffusion of the current barely occurs even if the impurity concentration is increased since

15   the etching stopper layer **15** has an extremely thin film thickness of about 10 nm.

Since the mobility of carriers is higher in an AlGaInP-based semiconductor material when it is doped with Zn than with Mg, a lower resistance can be achieved by doping the second p-type cladding layer **16** with Zn so that the series resistance of the semiconductor laser device is reduced advantageously.

20   Specifically, in the semiconductor laser device according to the first embodiment, the first p-type cladding layer **14** made of AlGaInP is doped with Mg at a concentration of about 5×10^{17} cm^{-3} so that the resistivity thereof becomes about 0.3 Ωcm. As shown in FIG. **3**, the threshold value of the semiconductor laser device at this time is about 40 mA. The output of the semiconductor laser device is not saturated even in an environment in which

25   the temperature is about 70 °C and the semiconductor laser device is operable with an

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that the resistivity of the first cladding layer is higher than a resistivity of the second cladding layer.

14. The method of claim 13, wherein

each of the first and second cladding layers is made of a compound semiconductor containing phosphorus,

the first impurity is magnesium, and

the second impurity is zinc.

15. The method of claim 13, wherein the step of forming the first cladding layer includes doping the first cladding layer with a third impurity in addition to the first impurity.

16. The method of claim 15, wherein

each of the first and second cladding layers is made of a compound semiconductor containing phosphorus,

the first impurity is magnesium, and

each of the second and third impurities is zinc.